Cold Silicon Detectors for COMPASS ◇

H. Angerer, A. Dinkelbach, J.M. Friedrich, S. Grabmüller, B. Ketzer, I. Konorov, and S. Paul

In the COMPASS experiment, double-sided silicon strip detectors perform high precision tracking in the beam telescope and, when required by the physics programme, also downstream of the target. In the beam time 2008, reactions of a pion beam scattering off protons under extremely small angles (e.g. central production) is under investigation, requiring very high tracking resolution around the target, which can be achieved by the setup as depicted in Fig. 1. Each station houses 2 detector modules and measures, by mounting them with a stereo angle of 5°, 4 projections of the particle trajectories.

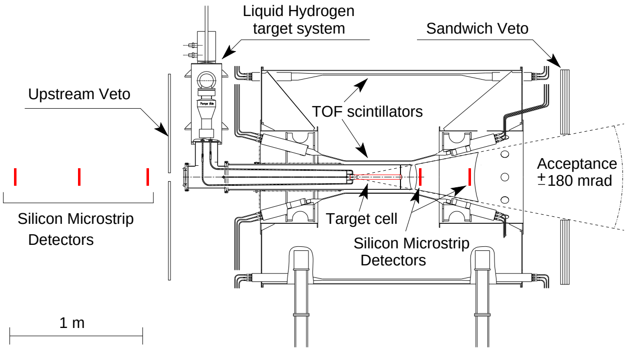

Fig. 1: Target region in the COMPASS 2008 setup. 3 silicon stations define the incoming beam, while 2 stations in a specially-shaped conical cryostat (under development by the University of Torino) measure the outgoing particle trajectories. A peculiar challenge is the integration of their infrastructure in the space beween the components of the inner TOF scintillator system.

Radiation damage limits the lifetime of the silicon wafers particularly for hadron beams and high particle fluxes. To endure the hadron beam time 2008, the lifetime of new detectors will be extended up to a factor of 5 by cooling the silicon to a temperature of 130 K with liquid nitrogen.

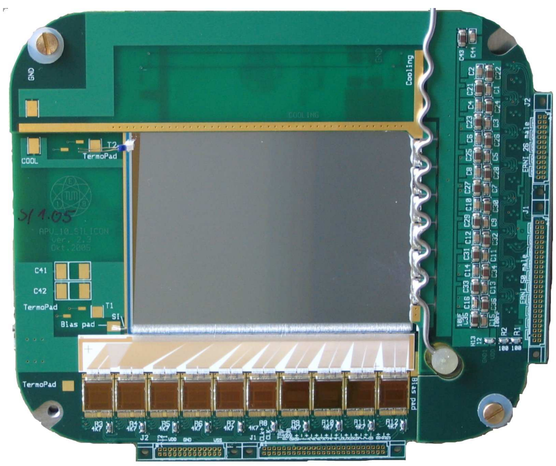

Fig. 2: Photograph of a detector module before soldering of the read-out cables. The wafer is supported between two L-shaped PCBs, holding the APV readout chips and the pitch adapters, which are visible here for the side with 1280 strips read out by 10 APVs.

The liquid nitrogen is flushed through a thin capillary, connected close to the silicon wafer on the printed circuit board (PCB) and conforming to a minimum material budget of the detector setup, located in the acceptance of the spectrometer. Several modifications compared to the initial development have been introduced in order to reduce the thermal stress between the wafer and the PCB, as illustrated also in Fig. 2: T-like cuts segment the PCB where the capillary and the wafer are connected, and where the PCB is coldest. The wafer is glued only on the two read-out sides. The capillary is meander-like bent, enhancing in addition the thermal contact.

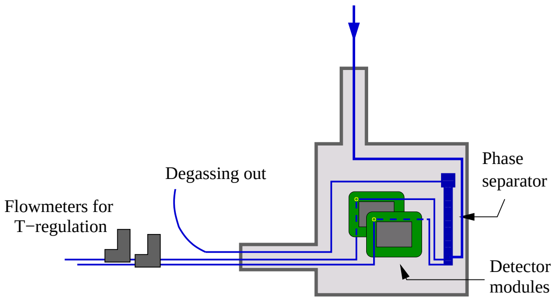

Fig. 3: Flow scheme near the detector modules in one of the beam stations.

A constant liquid nitrogen flow requires degassing at several stages on the way from the supply dewar in front of the experimental hall to the detector stations. The design of the distribution box, housing valves that allow the remote control of the detector cooling, has been changed such that a 100 ℓ buffer volume is included. Close to the detectors, regulated phase separators have been developed in such small shape, that it is possible to include them in the same shielding vacuum as the detectors themselves, as indicated in Fig. 3. The temperature on the detectors is stabilized by regulating the outgoing gas flux, which is achieved by a PLC (provided by the COMPASS Saclay group).

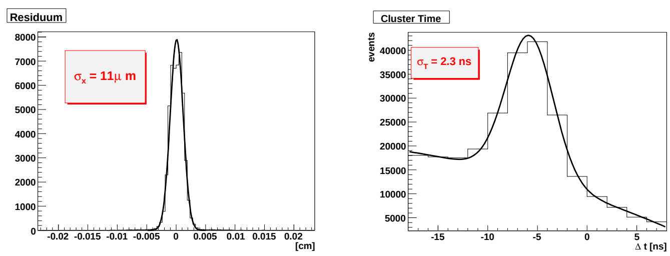

Fig. 4: Spatial (left) and time (right) resolution with a silicon detector cooled to 130 K during test operation in the COMPASS beam (November 2007).

A first module including the modifications described was tested with muon and hadron beams in the COMPASS environment at the end of the 2007 beam time. First results, indicating the expected operation features, are shown in Fig. 4.

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